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NEW ENCYRTIDAE (HYMENOPTERA) FROM PAPAYA MEALYBUG (*PARACOCCUS MARGINATUS* WILLIAMS AND GRANARA DE WILLINK) (HEMIPTERA: STERNORRHYNCHA: PSEUDOCOCCIDAE)

JOHN S. NOYES AND MICHAEL E. SCHAUFF

(JSN) Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.; (MES) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, % National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0168, U.S.A. (e-mail: mschauff@sel.barc.usda.gov)

Abstract.—Two new Encyrtidae, ***Pseudleptomastix mexicana*** and ***Acerophagus papayae***, are described and illustrated. Both species have been reared as part of exploration to find parasitoids of the papaya mealybug, *Paracoccus marginatus* Williams and Granara De Willink. Biological control programs currently underway are investigating these species, and we herein provide names and taxonomic information so these parasites can be utilized in the field.

Key Words: parasitoid, mealybug, biological control, Encyrtidae, Pseudococcidae

The papaya mealybug (PM), *Paracoccus marginatus* Williams and Granara De Willink, was described from Central America (Williams and Granara de Willink 1992) and apparently introduced to the Caribbean in 1994, where it spread among many of the islands (D. Meyerdirk, personal communication). It was found in Florida in 1998 (Miller and Miller 2002). The mealybug is believed to be native to Mexico and Central America. PM is a polyphagous feeder reported to attack 50 host plants, including food crops like *Papaya, Carica, Citrus, Capsicum,* and *Casava,* and ornamentals such as *Hibiscus, Plumeria,* and *Acalypha* (D. Meyerdirk, personal communication).

During 2000, fieldwork was conducted by one of us (MES), along with colleagues from the USDA-ARS and Colegio Postgraduados, Veracruz, and Colegio Postgraduados, Texcoco, Mexico to find species of parasitoids that might be of use in the biological control of *P. marginatus.* Several species, including *Anagyrus loecki* Noyes and Menezes, were discovered. These species are now being reared and released in the U.S. Virgin Islands, Puerto Rico, and Florida. We have determined that two of these are undescribed and we take this opportunity to provide names for them.

Abbreviations for morphological structures and museum as follows: AL = aedeagus length; AOL = distance between anterior and posterior ocelli; EL = maximum eye length; EW = maximum eye width; FV = minimum frontovertex width; FWL = forewing length; FWW = forewing width; GL = gonostylus length; HW = head width; HWW = hindwing width; HWL = hindwing length; MS = malar space; MT = midtibia length; OCL = minimum distance between posterior ocellus and occipital margin; OL = ovipositor length; OOL = minimum distance between posterior ocellus and eye margin; POL = minimum

distance between posterior ocelli; SL = scape length; SW = maximum scape width.

Abbreviations for Institutions are as follows. BMNH = The Natural History Museum, London, UK; INBIO = Instituto Nacional de Biodiversidad, Santo Domingo de Herdia, Costa Rica; USNM = National Museum of National History, Smithsonian Institution, Washington, DC.

Pseudleptomastix Girault (Tetracneminae)

Diagnosis.—*Female:* Head and mesosoma dark, base of tegula white, funicle 6-segmented, funicle segments longer than broad, subequal in size or shorter distally; clava 3-segmented, with sutures subparallel and never obliquely truncate; frontovertex between anterior ocellus and top of scrobes with very characteristic, regular, hexagonally reticulate sculpture of similar appearance to chicken-wire mesh and of mesh size about one-half to one-third diameter of anterior ocellus or slightly larger than an eye facet; mandibles with two teeth. *Male:* Similar to female but flagellar segments clothed in whorls of long setae, each much longer than diameter of segment; clava solid with subbasal scalelike structures ventrally.

Pseudleptomastix mexicana Noyes and Schauff, new species

(Figs. 1–6)

Female (holotype).—Length 0.97 mm. Head and thorax black with a slight to conspicuous sheen, especially on mesoscutum; frontovertex inconspicuously mixed purple and dark blue, mesoscutum brassy green; radicle dark brown; scape dark brown along dorsal margin to about three quarters along its length, this very nearly connected to ventral margin subapically, base of scape with a very narrow dark brown ring, remainder of scape pale orange; pedicel dark brown in basal half, apical half pale orange; flagellum more or less uniform brown, perhaps apical segments a little darker; tegula very pale yellow with a small brown apical spot; mesoscutum clothed in translucent, silvery white setae; fore coxa pale yellow, mid and hind coxae dark brown; hind femur dark brown, paler towards apex; fore femur and tibia slightly dusky orange; fore tarsus brown; mid and hind legs pale orange, hind tarsus dusky orange; forewing (Fig. 1) completely hyaline, venation brown; gaster dark brown with a coppery and purple sheen proximally otherwise with a brassy sheen.

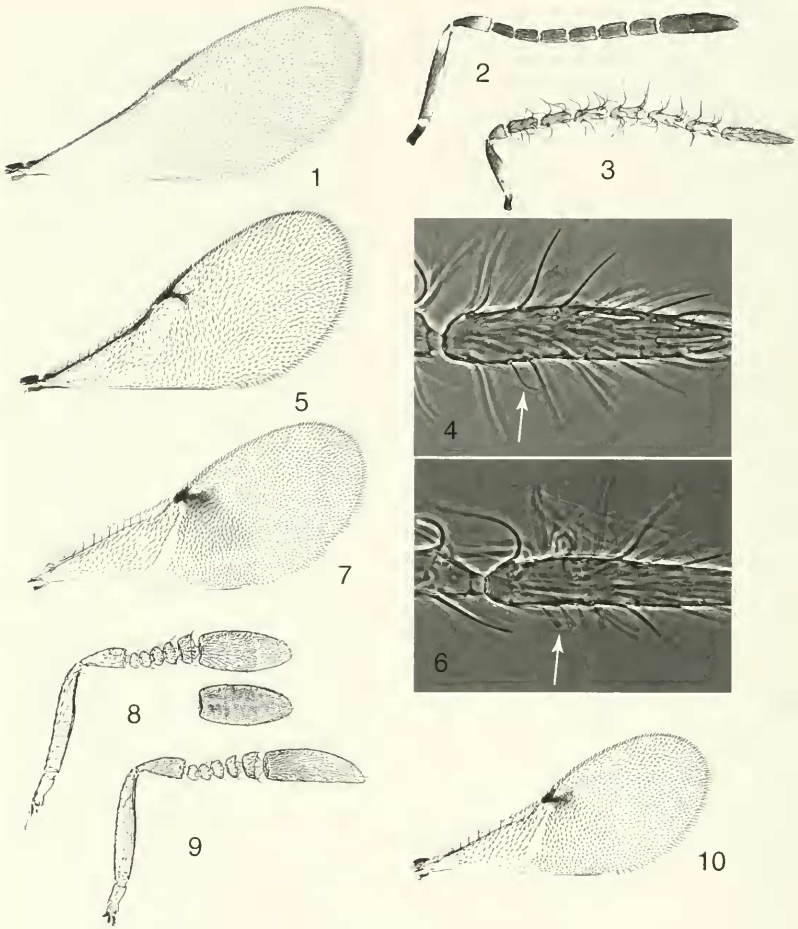
Head with raised, uniformly, polygonal reticulate sculpture on frontovertex of mesh size slightly larger than diameter of a facet; ocelli forming an angle of about 85°; antenna (Fig. 2) with pedicel about 2× as long as F1, funicle segments relatively short and stout, F1 about 2× as long as broad, F6 about 1.6× as long as broad and about 1.4× as long as F1. Relative measurements: HW 58, FV 22, POL 9, AOL 7, OOL 3, OCL 4, EL 41, EW 28, MS 15, SL 31, SW 5.

Mesoscutum shiny with shallow reticulate sculpture of distinctly smaller mesh than frontovertex; scutellum almost matt with clearly deeper, reticulate sculpture; forewing (Fig. 1) about 2.7× as long as broad; postmarginal vein about 2× as long as stigmal. Relative measurements: FWL 148, FWW 55; HWL 100, HWW 19.

Gaster with ovipositor hardly exserted, exserted part much less than 0.1× as long as gaster.

Relative measurements of paratypes: OL 53, GL 13, MT 94.

Male.—Length 0.56–0.84 mm. Generally similar to female in coloration but scape yellow in basal two-fifths or so, apex dark brown; pedicel dark brown; flagellum dark brown to testaceous; tegula white in basal half, apex brown; all funicle segments at least 2× as long as broad and clothed in long setae, longest of which are at least about 3× as long as width of any funicle segment (Fig. 3); clava ventrally with two or three slender, subbasal, apically curved scalelike structures, these difficult to distinguish from setae (Fig. 4); frontovertex about 0.5× head width; ocelli forming a slightly obtuse angle; forewing (Fig. 5) about 2.2× as long as broad; postmarginal



Figs. 1–10. 1–5, *Pseudleptomastix mexicana*. 1, Female forewing. 2, Female antenna. 3, Male antenna. 4, Male clava. 5, Male forewing. 6, *P. squammulata* male clava. 7–10, *Acerophagus papayae*. 7, Female forewing. 8, Female antenna. 9, Male antenna. 10, Male forewing.

vein of forewing mostly about 1.3× as long as stigmal. Relative measurements (specimen 1): HW 45, FV 25, POL 11, AOL 5.5, OOL 5, OCL 2.5, EL 24, EW 19, MS 17, SL 19, SW 6, FWL 113, FWW 48, HWL 76, HWW 15. Relative measurements (specimen 2): AL 32, MT 71.

Variation.—The female varies in length from 0.76–1.03 mm; the hind femur is normally significantly paler in apical one-third

or so, the base normally dark brown and the apex normally yellow or yellow brown; the linea calva may vary from being interrupted by four or five lines of setae and closed posteriorly by a single line of setae to more or less completely closed posteriorly by eight or nine lines of setae.

Hosts.—Reared from *Paracoccus marginatus* on *Carica papaya* L. (Caricaceae).

Distribution.—Mexico (Michoacán), Costa Rica.

Material examined.—Holotype ♀, MEXICO, Michoacán, Mpio Gabriel Zamora, Santa Casilda, 9.vi.1999 Coll. #58, H. Gonzalez, J. Villanueva, D.R. Miller (SEL), MxSEL(DRM)-99-4, ex *Paracoccus marginatus* on *Carica papaya*, BIRL-99-1d #16. Paratypes: MEXICO, 39 ♀, 68 ♂, same data as holotype. Other specimens: COSTA RICA, 1 ♂, Guanacaste, Santa Rosa NP, Hacienda 3-0, 1-22.vi.1985 (D. Janzen, I.D. Gauld); 1 ♂, Guanacaste, Santa Rosa NP, Hacienda 2-C, 4-24.v.1986 (D. Janzen, I.D. Gauld); 1 ♀, Guanacaste, Santa Rosa NP, H-1-0, 4-25.iv.1987 (D. Janzen, I.D. Gauld); 2 ♀, Guanacaste, Santa Rosa NP, H-1-0, 16.v-6.vi.1987 (D. Janzen, I.D. Gauld); 1 ♀, Guanacaste, Santa Rosa NP (incorrectly labeled as Guanacaste NP), near HQ, 1-10.iii.1990 (J.S. Noyes); 2 ♀, Guanacaste, Santa Rosa NP, 300 m, 7 km E HQ "small house," 9-10.iii.1990 (J.S. Noyes). Holotype in USNM, paratypes in USNM, BMNH, INBIO.

Etymology.—This species is named for the country of the type locality.

Comments.—*Pseudleptomastix mexicana* is very similar to *P. squammulata* (Girault) and, in fact, the Costa Rican material included here in the type series was identified previously as that species (Noyes 2000). The minor difference in coloration of the scape appears to be consistent. In *P. mexicana*, the ventral margin of the scape is always yellow, whilst in *P. squammulata* the proximal three-quarters of the scape is completely dark brown. At this point we do not know the significance of the relative lengths of the funicle segments in the females. Specimens which have the funicle segments relatively longer with F1 as long as or nearly as long as the pedicel and F6 about 2× as long as broad can be considered typical of *P. squammulata*, whilst specimens which have F1 about half as long as the pedicel and F6 about 1.5× as long as broad, but with the coloration of the scape as in *P. squammulata*, may represent a dark form of *P. mexicana* or an as yet undescribed species. Specimens with relatively shorter funicle segments and darker scape coloration have been examined from Costa Rica (BMNH) and Texas (BMNH). The males can be separated on more robust differences in antennal structure. In *mexicana*, the longest setae on the funicle are only about 3× as long as the diameter of the segments and there are only two or three, very slender, apically curved scalelike structures near the base of the clava on the ventral surface which are relatively difficult to separate from normal setae on the clava (Fig. 4). In *P. squammulata*, the longest setae on the funicle are about 4× as long as the diameter of the segments and there are three or four, spatulate, scalelike structures near the base of the clava on the ventral surface which are very easy to distinguish from normal setae on the clava (Fig. 6). Males of the two species can be separated more reliably than the females. It is likely that the significance of differences in the relative dimensions of the funicle segments of the female antenna could be determined by comparing reared series of the two species which have been subjected to differing environmental conditions.

Aceroplagus Smith (Encyrtinae)

Diagnosis.—*Female:* Body yellow or orange with occasional dark markings; antenna unicolorous with 5 short, transverse to quadrate funicles and large 3-segmented clava; mandibles with three teeth, middle tooth longest; ovipositor generally at least slightly exserted. *Male:* Almost identical to female except for genitalia and single segmented clava.

Acerophagus papayae Noyes and Schauff, new species
(Figs. 7–10)

Female (holotype).—Length, including ovipositor, 0.85 mm. Head, including antennae, generally pale orange with F5 and base of clava slightly dusky; ocelli red; thorax generally pale orange; neck of pronotum brown, posterior margin translucent and side a little paler, almost yellow; posterior margin of pronotum, mesoscutum and scutellum clothed in conspicuous, brown setae; tegula very pale orange with apex pale grey brown; side and venter of thorax and legs slightly paler than thoracic dorsum; (Fig. 7) with an inconspicuous, subcircular, infuscate area from stigmal vein to posterior wing margin, otherwise wings hyaline; propodeum mostly pale orange; but brown laterally on dorsum; gaster mostly pale orange but brown near cercal plates and dorsally along posterior margins of tergites III to V (abdominal V to VII) and indistinctly proximally in middle of tergite VI; ovipositor sheath pale orange, apex brown.

Frontovertex slightly shiny with fine, regular, reticulate sculpture of mesh size slightly smaller than diameter of a facet; ocelli forming an angle of about 75°, posterior ocellus slightly closer to eye than to occipital margin; inner eye margins subparallel, frontovertex about twice as long as broad, one-third head width and hardly becoming wider anteriorly; scape about 4.5× as long as broad; other proportions of antenna as in Fig. 8, pedicel nearly as long as F1–F4 combined and clava slightly shorter than pedicel and funicle together with outer suture slightly oblique and complete, third segment slightly more than half length of clava. Relative measurements: HW 47, FV 15, FWL 33, POL 6, AOL 4.5, OOL 2, OCL 3, EL 33, EW 25, MS 18, SL 26, SW 6.

Mesoscutum and scutellum with similar sculpture, both similar to that on frontovertex but slightly finer and distinctly shallower, piliferous punctures distinct but small and separated by much more than their own diameters; forewing venation and setation as in Fig. 7. Relative measurements: FWL 120, FWW 49; HWL 85, HWW 20.

Gaster with exserted part of ovipositor about 0.2× length of gaster or 0.7× length of midtibial spur.

In paratypes, funicle with linear sensilla present only on F5, apical segment of clava nearly 0.6× as long as clava; maxillary palpus 4-segmented. Relative measurements: OL 68, GL 24, MT 59.

Male.—Length 0.44–0.66 mm. Generally very similar to female but for unsegmented clava (Fig. 9) and genitalia. Gaster mostly with apical tergites more extensively darkened than in female; forewing (Fig. 10) with infuscate area less conspicuous, below stigmal vein only and hardly extending towards posterior wing margin. Relative measurements: AL 18.5, MT 47.

Variation.—The female varies in length, including ovipositor about 0.58–0.77 mm. The strength of the infuscation on the forewing of the female can vary, in some specimens it is very indistinct with the forewing medially appearing to be almost hyaline whilst in other specimens it is strong and distinct.

Hosts.—Reared from *Paracoccus marginatus* on *Carica papaya*.

Distribution.—Mexico (Michoacán).

Material examined.—Holotype ♀, MEXICO, Michoacán, Mpio Gabriel Zamora, Santa Casilda, 9.vi.1999 Coll. #58, H. Gonzalez, J. Villanueva, D.E. Miller (SEL), MxSEL(DRM)-99-4, ex *Paracoccus marginatus* on *Carica papaya*, BIRL-99-Id #15. Paratypes: 77 ♀, 48 ♂, same data as holotype. Holotype in USNM, paratypes in USNM, BMNH.

Etymology.—This species is named for the papaya plant on which its host feeds.

Comments.—*Acerophagus papayae* differs from all other described species of the genus by the combination of the relatively narrow frontovertex (about one-third head width or about 2× as long as wide), infus-

cate forewings and generally yellow or orange colour of the body with dark markings only on the propodeum and dorsum of the gaster. It appears to be closest to *texanus*, females of both species having the third segment of the clava more than half as long as the clava whereas in most other species the third segment is less than half as long as the clava. *Acerophagus papayae* differs from *A. texanus* in the complete outer suture of the clava, the less extensive infuscate areas of the forewing and the banded gaster. In *A. texanus* the outer suture of the clava is incomplete, the forewing is infuscate below the submarginal vein and abdomen is uniformly orange yellow, whilst in *A. papayae* the forewing is completely hyaline below the submarginal vein and the propodeum is marked with brown and the gaster has at least two transverse, brown bands visible dorsally. *Acerophagus papayae* seems to be close to *A. californicus* or *A. nubilipennis*, these species also having the forewing with an infuscate area medially below the stigmal vein and the gaster pale with dark cross bands from the cercal plates. However, these species have a broader frontovertex and relatively short third segment of clava. In both *A. californicus* and *A. nubilipennis* the frontovertex is about 1.5× as long as wide and the third segment of the clava is less than 0.5× as long as the clava. In Rosen's (1969) key to species of *Acerophagus*, females of *A. papayae* run to couplet 5. The other species which run here (*A. debilis*, *A. luteolus* and *A. antennalis*) have the forewing completely hyaline or only faintly yellow in the proximal half. The males would run to best to *A. antennalis* or *A. texanus*. The new species differs from *A. antennalis* in the presence of a weak infuscate cloud below the stigmal vein and slightly more transverse funicle segments. In males of *A. antennalis* the forewing is hyaline or at most faintly yellow proximally and F5 is about 1.3× as wide as long, whereas in *A. papayae* F5 is at least 1.5× as wide as long. It differs from *A. texanus* on the narrower frontovertex, relatively longer clava and forewing being less extensively infuscate. In *A. texanus*, the frontovertex is about 1.5× as long as wide, the clava is about as long as the funicle and the forewing is infuscate below the apex submarginal vein, whereas in *A. papayae* the frontovertex is about 2× as long as wide, the clava is longer than the funicle and the forewing is infuscate only below the stigmal vein.

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